CLAIMS

1. A peptide selected from the following (a), (b), (c) or (d):

(a) a peptide consisting of the amino acid sequence as shown in SEQ ID NO: 4;

(b) a peptide which consists of the amino acid sequence as shown in SEQ ID NO: 4 having addition, deletion or substitution of one or a plurality of amino acids and has β-ionone ring-2-hydroxylase activity;

(c) a peptide which consists of an amino acid sequence having a 50% or more identity with the amino acid sequence as shown in SEQ ID NO: 4 and has β-ionone ring-2-hydroxylase activity; or

(d) a bacterium-derived peptide which is encoded by a DNA consisting of the nucleotide sequence as shown in SEQ ID NO: 3 or a DNA hybridizable to a complementary DNA to said DNA under stringent conditions and has β-ionone ring-2-hydroxylase activity.

2. A gene encoding a peptide selected from the following (a), (b), (c) or (d):

(a) a peptide consisting of the amino acid sequence as shown in SEQ ID NO: 4;

(b) a peptide which consists of the amino acid sequence as shown in SEQ ID NO: 4 having addition, deletion or substitution of one or a plurality of amino acids and has β-ionone ring-2-hydroxylase activity;

(c) a peptide which consists of an amino acid sequence having a 50% or more identity with the amino acid sequence as shown in SEQ ID NO: 4 and has β-ionone ring-2-hydroxylase activity; or

(d) a bacterium-derived peptide which is encoded by a DNA consisting of the nucleotide sequence as shown in SEQ ID NO: 3 or a DNA hybridizable to a complementary DNA to said DNA under stringent conditions and has β-ionone ring-2-hydroxylase activity.

3. A microorganism obtainable by introducing the gene according to claim 2 thereinto, wherein the microorganism is capable of introducing a hydroxyl group at the position 2 carbon of β-ionone ring.

4. A microorganism obtainable by introducing the gene according to claim 2 and other carotenoid biosynthesis genes thereinto, wherein the microorganism is capable of

introducing a hydroxyl group at the position 2 carbon of β-ionone ring.

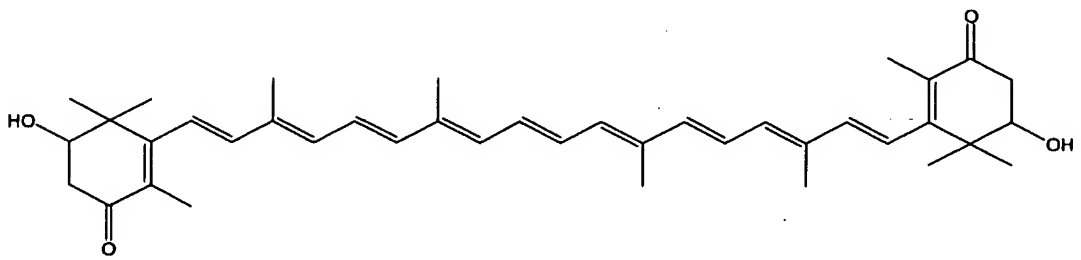
5. The microorganism according to claim 4, wherein the other carotenoid biosynthesis genes are all or a part of a gene cluster required for synthesizing β-ionone ring-containing carotenoids from farnesyl pyrophosphate.

6. The microorganism according to any one of claims 3 to 5, wherein the microorganism is *Escherichia coli*.

7. A method of preparing a hydroxylated carotenoid, comprising culturing the microorganism according to any one of claims 3 to 6 in a medium and obtaining from the resultant culture or cells a carotenoid which is hydroxylated at the position 2 carbon of its β-ionone ring.

8. The method according to claim 7, wherein the carotenoid which is hydroxylated at the position 2 carbon of its β-ionone ring is β,β-carotene-2-ol (2-hydroxy-β-carotene), β,β-carotene-2,2'-diol (2,2'-dihydroxy-β-carotene), caloxanthin (2-hydroxyzeaxanthin), nostoxanthin (2,2'-dihydroxyzeaxanthin), 2-hydroxy-β,β-carotene-4,4'-dione (2-hydroxycanthaxanthin), 2,2'-dihydroxy-β,β-carotene-4,4'-dione (2,2'-dihydroxycanthaxanthin), 2-hydroxyastaxanthin or 2,3,2',3'-tetrahydroxy-β,β-carotene-4,4'-dione (2,2'-dihydroxyastaxanthin).

9. 2,2'-dihydroxy-β,β-carotene-4,4'-dione (2,2'-dihydroxycanthaxanthin) represented by the following chemical formula (I):



(I)

10. An antioxidant comprising 2,2'-dihydroxy-β,β-carotene-4,4'-dione (2,2'-dihydroxycanthaxanthin) or 2-hydroxy-β,β-carotene-4,4'-dione (2-hydroxycanthaxanthin) as an active ingredient.

11. A gene encoding a peptide selected from the following (e), (f) or (g):

(e) a peptide consisting of the amino acid sequence as shown in SEQ ID NO: 30;

(f) a peptide which consists of the amino acid sequence as shown in SEQ ID NO: 30 having addition, deletion or substitution of one or a plurality of amino acids and has β-ionone ring-3-hydroxylase activity; or

(g) a bacterium-derived peptide which is encoded by a DNA consisting of the nucleotide sequence as shown in SEQ ID NO: 29 or a DNA hybridizable to a complementary DNA to said DNA under stringent conditions and has β-ionone ring-3-hydroxylase activity.

12. A microorganism obtainable by introducing the gene according to claim 11 thereinto, wherein the microorganism is capable of introducing a hydroxyl group at the position 3 carbon of β-ionone ring.

13. A microorganism obtainable by introducing the gene according to claim 11 and other carotenoid biosynthesis genes thereinto, wherein the microorganism is capable of introducing a hydroxyl group at the position 3 carbon of β-ionone ring.

14. The microorganism according to claim 13, wherein the other carotenoid biosynthesis genes are all or a part of a gene cluster required for synthesizing β-ionone ring-containing carotenoids from farnesyl pyrophosphate.

15. The microorganism according to any one of claims 12 to 14, wherein the microorganism is *Escherichia coli*.

16. A method of preparing a hydroxylated carotenoid, comprising culturing the microorganism according to any one of claims 12 to 15 in a medium and obtaining from the resultant culture or cells a carotenoid which is hydroxylated at the position 3 carbon of its β-ionone ring.

17. A gene encoding a peptide selected from the following (h), (i) or (j):

(h) a peptide consisting of the amino acid sequence as shown in SEQ ID NO: 32;

(i) a peptide which consists of the amino acid sequence as shown in SEQ ID NO: 32 having addition, deletion or substitution of one or a plurality of amino acids and has geranylgeranyl pyrophosphate synthase activity; or

(j) a bacterium-derived peptide which is encoded by a DNA consisting of the nucleotide sequence as shown in SEQ ID NO: 31 or a DNA hybridizable to a complementary DNA to said DNA under stringent conditions and has geranylgeranyl pyrophosphate synthase activity.